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(71) Applicant: AMERICAN CYANAMID COMPANY
1937 West Main Street P.O. Box 60
Stamford Connecticut 06904-0060(US)

(72) Inventor: Cibulskas, Algrid S.
28 Westwood Road
Stamford, Connecticut 06902(US)
Inventor: Asbell, Henri R.
51 Gilrix Drie
Martinez, California 94553(US)

(74) Representative: Wächtershäuser, Günter, Dr.
Tal 29
W-8000 München 2(DE)

(54) Use of blends of mannich acrylamide polymers and dimethyldiallylammonium halide polymers for flocculating enzyme broth streams.

(57) Blends of Mannich acrylamide polymers and dimethyldiallylammonium halide polymers have been found to be superior flocculants for enzyme broth streams yielding higher solid compaction and greater supernatant clarities than the use of either polymer alone.

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USE OF BLENDS OF MANNICH ACRYLAMIDE POLYMERS AND DIMETHYLDIALLYLAMMONIUM HALIDE POLYMERS FOR FLOCCULATING ENZYME BROTH STREAMS

Background of the Invention

The production of enzymes by fermentation has been carried out for many years. Fermentation is usually carried out in stainless steel equipment i.e. mixing and blending tanks, and seed and main fermentators. Constant temperature, automatic foam and pH controllers and air purifiers are employed since the absence of foreign microorganisms is essential. Tap water is generally combined with the media ingredients and enzyme recovery begins as soon as fermentation is terminated. The medium is cooled and centrifuges are used to remove bacteria and large insolubles from the supernatant followed by filters to separate smaller particles. Enzyme is concentrated and removed from the filtrate by the addition of a precipitating agent. The precipitate is then further treated by additional filtering and drying etc. and is then standardized such as by using sodium chloride.

Proteases are enzymes which have been found to be particularly useful in industrial areas including cheese making, meat tenderizing, bread baking, beer haze elementation, digestive aid preparations, garment cleaning, pharmaceutical preparation and the like. Those proteases produced by cultivation can be used as food additives.

Characteristic of the protease enzyme broth is the formation of a suspension that does not settle. Upon centrifugation of a sample in a test tube, solids will be deposited in the lower 70% of the test tube and only the upper 30% of the tube will be clear supernatant solution.

One of the most difficult problems involving enzyme production is the isolation of the enzyme from its broth. Although many flocculating agents have been used for the precipitation of enzyme broths, most have suffered from some disability which renders the agent less attractive commercially. Examples of flocculants used commercially include epichlorohydrin-dimethylamine condensation products cross-linked with diethylenetriamine/dicyanamide; Mannich acrylamide polymers and polydimethyldiallylammonium halides. These additives, although tolerable, ofttimes fail to result in the isolation of the enzyme sufficiently e.g. the solids are not compacted; the supernatant has poor clarity, etc. Thus, the search for more effective flocculants is continuing and the discovery of useful materials which do not suffer from the deficiencies of the existing commercial flocculants would satisfy a long felt industrial need.

Summary Of The Invention

The present invention relates to a process for precipitating aqueous enzyme broths comprising using, as the flocculating agent, a blend of a Mannich acrylamide polymer and a diallyldimethylammonium halide polymer, which blend has been found to provide more effective flocculation of precipitate than either of these known flocculants alone.

Description Of The Invention Including Preferred Embodiments

This invention relates to a process for precipitating an aqueous enzyme broth which comprises adding to said broth a flocculant comprising a blend of 1) a Mannich acrylamide polymer and 2) a dimethyldiallylammonium halide polymer.

The blends are composed of the two polymers 1); 2) in a ratio of 3:1 to 1:30, by weight, real polymer solids, respectively, preferably 1:1.5 to 1:7, respectively.

The Mannich acrylamide polymers are generally well known in the art, examples thereof being disclosed in U.S. Patent No. 4,137,164, hereby incorporated herein by reference. Generally, these polymers are homopolymers of acrylamide or copolymers thereof with such commoners as acrylonitrile, methacrylamide, acrylic acid etc. in amounts up to about 50%, preferably 5-50% of the resultant copolymer. The polymers have molecular weights ranging from about 10,000 to about 3,000,000 and are chemically modified to provide dimethylaminomethyl groups to the extent that the polymer contains 25-100 mol percent of these groups, preferably at least 40 mol percent.

The dimethyldiallylammonium halide (DADM) polymers are likewise known in the art, examples thereof being disclosed in U.S. Patent No. 4,092,467, hereby incorporated herein by reference. These polymers are homopolymers of DADM or copolymers thereof with such monomers as acrylamide, vinyl pyrrolidone, etc. in amounts up to about 20% of the resultant polymer. These polymers have Intrinsic Viscosities ranging from about 0.1-4.00 deciliters per gram. The halide can be chloride, fluoride, bromide or iodide.

The polymer blend may be added to the enzyme broth as such or the two polymers may be added individually but as near the same time as possible, since the enhanced benefit of the polymers is attributed to their presence in the broth coincidentally. The amount of the blend added to the broth is that effective to produce the clearest supernatant and achieve the highest solid compaction as possible. Generally, amounts ranging from about 10 to 100 grams of polymer blend per liter of broth, preferably from about 25-75 grams per liter, is effective, although higher or lower amounts may be useful in specific instances.

The following examples are set forth for purposes of illustration only and are not to be construed as limitations on the present invention. Products A and B are set forth in the following tables, with respect to the amounts employed, as 0.065% aqueous polymer solutions while Product C is expressed as a 20.0% aqueous polymer solution. Clarity is measured by UV absorbance at 660 microns.

In the following examples, the Mannich acrylamide polymers employed are each Mannich polyacrylamide of 70% aminomethylation and are further designated as follows:

Product	Percent Solids	Brookfield Viscosity-cps
A	5.9-6.4%	26,000-34,000
B	5.5-6.1	34,000-46,000

The dimethyldiallylammonium halide polymer is polydimethyldiallyammonium chloride further designated as follows:

Product	Percent Solids	Intrinsic Viscosity-cps
C	19.5-20.5	2.0-3.5

In order to test the effectiveness of various polymers in flocculating enzyme broths, the following test procedure is utilized: To 5ml of broth in a 15ml clinical, graduated centrifuge tube are added 5ml. samples of various concentrations of the polymer solutions. Each sample is mixed by inverting the stoppered clinical tube 20 times, the clinical tube is then centrifuged for 5 minutes and the volume of the compacted enzyme is visually measured. The lower the value, the better. In addition, the clarity of the supernatant is measured by UV absorbance at 660 microns. A value of 0.3-0.4% is acceptable and below 0.1 is superior.

Table I is a measure of the effect of single polymer flocculants on the precipitation of enzyme broths. It is a comparative table showing that although Products A, B and/or C individually may perform effectively with regard to compaction (% volume solids) or clarity, the flocculants alone fail to perform satisfactorily as regards both criteria.

TABLE I

Effect of Single Polymer Flocculants on The Flocculation of Enzyme Broth

Exp. No.	Flocculant	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
	None	-	-	72	poor
1	C 1st run	5	20	28	1.58
		10	20	27	0.622
		15	20	26	0.477
		20	20	26	0.438
		25	20	27	0.393
2	C 2nd run	10	20	28	-
		10	20	29	0.879
		15	20	24	0.338
		20	20	26	0.306
		25	20	26	0.245
3	C 3rd run	5	20	28	1.14
		10	20	27	0.432
		15	20	24	0.303
		20	20	24	0.272
		25	20	25	0.251
4	C 4th run	5	20	31	0.649
		10	20	31	0.577
		15	20	31	0.299
		20	20	31	0.240
		25	20	31	0.232

TABLE I (Cont'd)

Exp. No.	Flocculant Product	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
5	A	15	20	-	-
		25	20	18	1.72
		35	20	18	0.272
6	A	15	20	20	0.253
		17.5	20	20	0.225
		20	20	19	0.154
7	B 1st run	20	20	15	-
		30	20	15	0.116
		40	20	17	0.258
8	B 2nd run	15	20	-	-
		25	20	18	1.68
		35	20	18	0.253
9	B	15	20	21	0.796
		17.5	20	22	0.298
		20	20	20	0.184

Table II reflects the unexpectedly superior result achieved when using blends of C and B polymers on an enzyme broth. As can be seen, in this instance, as the blend approaches a 1/3 mixture, the compaction and the clarity are drastically improved.

TABLE II

Improved Compaction and Clarity of Supernatant with Polymer Blends

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
10	C		15	20	23	0.384
			20	20	23	0.309
			25	20	24	0.319
11	B		20	20	15	Poor
			30	20	15	0.116
			40	20	17	0.258
12	B/C	1.3/1	20	20	18	0.588
			30	20	17	0.270
			40	20	18	0.614
13	B/C	1/3	15	20	17	0.218
			20	20	19	0.101
			25	20	19	0.093

Examples 14-20 of the Table III represent comparative results as in Table II using Product A instead of Product B. As can be seen, the blends result in clarities superior to either polymer alone. The compaction values are not as good for the blends as Product A alone; however, the excellent overall results achieved by the blends are clearly shown.

In Examples 21-26 varying ratios of Product B to Product C are shown to be excellent as the level of

Polymer B increases, especially with regard to the compaction. Example 24, at 35 g/l results in the outstanding value of 0.069 with a compaction value of 20.

The blends of A/C and B/C (Examples 27-32) show exceptional clarity in conjunction with acceptable compaction, compare Example 9.

Examples 33-43 form further support for the unexpected synergistic results achieved by the blends in that compaction falls well within the accepted range and increasingly superior clarity at dosage of 10-20 g/l are set forth.

An enzyme fermentation broth is treated in Examples 44-52 with the benefits of the polymer blends being clearly evident. Examples 53-62 reflect the same inventive trend.

TABLE III

Polymer Blend Ratios
vs.
Effect on Compaction and Supernatant Clarity

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
14	C	-	15	20	30	0.824
			25	20	28	0.465
			35	20	29	0.359
15	A	-	15	20	-	-
			25	20	18	1.72
			35	20	18	0.275
16	A/C	3/1	15	20	18	0.609
			25	20	20	0.629
			35	20	20	0.128
17	A/C	1/1.5	15	20	20	0.955
			25	20	20	0.230
			35	20	20	0.190
18	A/C	1/3	15	20	20	0.472
			25	20	20	0.172
			35	20	20	0.131
19	A/C	1/7	15	20	20	0.263
			25	20	22	0.153
			35	20	23	0.150

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
20	A/C	1/30	15	20	24	0.290
			25	20	24	0.166
			35	20	25	0.208
21	B	-	15	20	-	-
			25	20	18	1.680
			35	20	18	0.253
22	B/C	3/1	15	20	20	0.017
			25	20	19	0.672
			35	20	19	0.152
23	B/C	1/1.5	15	20	18	1.530
			25	20	20	0.198
			35	20	20	0.114
24	B/C	1/3	15	20	20	0.314
			25	20	20	0.260
			35	20	20	0.069
25	B/C	1/7	15	20	20	0.306
			25	20	20	0.103
			35	20	23	0.172
26	B/C	1/30	15	20	24	0.299
			25	20	24	0.125
			35	20	25	0.298

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
27	A/C	3/1	10	20	20	0.479
			15	20	22	0.098
			20	20	19	0.119
			25	20	20	0.069
28	A/C	1/3	10	20	23	0.176
			12.5	20	21	0.058
			15	20	20	0.070
			17.5	20	20	0.034
			20	20	20	0.053
29	A/C	1/30	15	20	25	0.046
			20	20	23	0.031
			25	20	23	0.039
30	B/C	3/1	10	20	-	-
			12.5	20	-	0.484
			15	20	-	0.194
			17.5	20	-	0.135
			20	20	-	0.095
31	B/C	1/3	10	20	-	0.253
			12.5	20	20	0.124
			15	20	19	0.106
			17.5	20	19	0.063
			20	20	20	0.066

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
32	B/C	1/30	10	20	24	0.138
			12.5	20	23	0.073
			15	20	22	0.056
			17.5	20	23	0.043
			20	20	23	0.031
33	C	-	10	20	34	0.563
			15	20	31	0.340
			17.5	20	31	0.319
			20.0	20	30	0.290
			22.5	20	30	0.095
			25	20	30	0.103
34	A	-	15	20	20	0.253
			17.5	20	20	0.225
			20	20	19	0.154
35	A/C	3/1	10	20	23	0.932
			12.5	20	21	0.244
			15	20	21	0.202
			17.5	20	21	0.096
			20	20	22	0.146

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
36	A/C	1.3/1	10	20	21	0.367
			12.5	20	22	0.237
			15	20	20	0.150
			17.5	20	22	0.089
			20	20	21	0.118
37	A/C	1/1.5	10	20	23	0.329
			12.5	20	22	0.207
			15	20	20	0.166
			17.5	20	21	0.102
			20	20	21	0.109
38	A/C	1/3	15	20	22	0.145
			17.5	20	22	0.177
			20	20	21	0.072
39	B	-	15	20	21	0.796
			17.5	20	22	0.298
			20	20	20	0.184
40	B/C	3/1	10	20	23	0.932
			12.5	20	21	0.244
			15	20	21	0.202
			17.5	20	21	0.096
			20	20	22	0.146

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
41	B/C	1.3/1	10	20	21	0.367
			12.5	20	22	0.237
			15	20	20	
			17.5	20	19	0.129
42	B/C	1/1.5	10	20	20	0.742
			12.5	20	20	0.232
			15	20	19	0.176
			17.5	20	19	0.125
			20	20	20	0.120
43	B/C	1/3	15	20	20	0.184
			17.5	20	20	0.106
			20	20	20	0.095
44	C	-	10	20	30	0.462
			12.5	20	30	0.388
			15	20	29	0.369
			17.5	20	30	0.365
			20	20	32	0.348
			22.5	20	32	0.345

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
45	A/C	3/1	12.5	20	18	0.859
			15	20	19	0.565
			17.5	20	19	0.403
			20	20	18	0.306
			22.5	20	20	0.263
			25	20	21	0.233
46	A/C	1.3/1	12.5	20	20	0.481
			15	20	20	0.390
			17.5	20	20	0.276
			20	20	20	0.259
			22.5	20	22	0.219
			25	20	22	0.188
47	A/C	1/1.5	12.5	20	21	0.498
			15	20	21	0.388
			17.5	20	21	0.318
			20	20	22	0.288
			22.5	20	22	0.231
			25	20	23	0.251
48	A/C	1/3	12.5	20	20	0.331
			15	20	21	0.282
			17.5	20	22	0.253
			20	20	23	0.140
			22.5	20	24	0.201
			25	20	25	0.224

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
49	B/C	3/1	12.5	20	20	-
			15	20	18	0.656
			17.5	20	18	0.148
			20	20	19	0.381
			22.5	20	18	0.197
			25	20	19	0.327
50	B/C	1.3/1	12.5	20	17	1.01
			15	20	18	0.505
			17.5	20	18	0.321
			20	20	18	0.272
			22.5	20	19	0.208
			25	20	20	0.205
51	B/C	1/1.5	12.5	20	18	0.522
			15	20	19	0.331
			17.5	20	20	0.243
			20	20	19	0.173
			22.5	20	20	0.145
			25	20	19	0.130
52	B/C	1/3	12.5	20	20	0.299
			15	20	20	0.240
			17.5	20	20	0.166
			20	20	20	0.155
			22.5	20	21	0.152
			25	20	22	0.160

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/1	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
53	A/C	3/1	16	20	21	0.266
			18	20	22	0.303
			20	20	20	0.195
			22	20	20	0.345
			24	20	20.5	0.248
54	A/C	1/1.5	16	20	21.5	0.282
			18	20	22	0.296
			20	20	21	0.177
			22	20	20	0.209
			24	20	20.5	0.177
55	A/C	1/3	16	20	21	0.082
			18	20	22.5	0.065
			20	20	22	0.090
			22	20	21	0.054
			24	20	22	0.031
56	A/C	1/7	16	20	23	0.222
			18	20	23	0.058
			20	20	22.5	0.016
			22	20	23	0.032
			24	20	24	0.010

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
57	A/C	1/30	16	20	26	0.290
			18	20	25	0.123
			20	20	25	0.077
			22	20	25	0.036
			24	20	25	0.032
58	B/C	3/1	16	20	20	0.171
			18	20	20	0.145
			20	20	20	0.151
			22	20	20	0.117
			24	20	20	0.070
59	B/C	1/1.5	16	20	20	0.146
			18	20	20	0.120
			20	20	20	0.115
			22	20	20	0.113
			24	20	20	0.102
60	B/C	1/3	16	20	20	0.162
			18	20	20	0.103
			20	20	20	0.095
			22	20	19.5	0.093
			24	20	19.5	0.074

TABLE III (Cont'd)

Exp. No.	Flocculant	Ratio	g/l	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
61	B/C	1/7	16	20	20.5	-
			18	20	20.5	0.037
			20	20	20	0.039
			22	20	21.5	0.041
			24	20	21.5	0.034
62	B/C	1/30	16	20	25	0.283
			18	20	24	0.102
			20	20	24	0.100
			22	20	25	0.059
			24	20	24	0.029

Table IV reflects the results of increasing the polymer blend dosage rate in Examples 63-72. As can be seen, upon treating an enzyme fermentation broth, increased blend dosages results in magnificent clarity values as low as 0.018 although compaction values are somewhat sacrificed.

In Examples 73-81, an enzyme broth is treated and at rather low dosage rates, the combined compaction/clarity values are considered acceptable.

TABLE IV

Polymer Blend Effect on Compaction and Supernatant Clarity on an Enzyme Broth

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
63	A/C	3/1	-	-	-	-
			40	20	32	--
			50	20	30	0.506
64	A/C	1/1.5	30	20	30	1.300
			40	20	30	0.088
			50	20	-	-
65	A/C	1/3	30	20	-	-
			40	20	30	0.140
			50	20	31	0.096
66	A/C	1/7	-	-	-	-
			40	20	30	0.074
			50	20	30	0.040
67	A/C	1/3	-	-	-	-
			40	20	30	0.056
			50	20	28	0.018
68	B/C	3/1	40	20	28	-
			50	20	30	0.291

TABLE IV (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
69	B/C	1/1.5	40	20	31	1.580
			50	20	29	0.172
70	B/C	1/3	40	20	30	0.280
			50	20	30	0.052
71	B/C	1/7	40	20	30	0.142
			50	20	30	0.044
72	B/C	1/30	30	20	30	0.063
			40	20	30	0.027
			50	20	-	-
73	C	-	10	20	54	-
			12.5	20	48	-
			15	20	45	-
			17.5	20	45	1.00
			20	20	37	0.042
			22.5	20	35	0.032
74	A/C	1/3	22.5	20	32	-
			25	20	30	0.258
			27.5	20	30	0.178

TABLE IV (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
75	A/C	1/7	15	20	33	0.375
			20	20	29	0.156
			22.5	20	28	0.178
			25	20	28	0.089
			27.5	20	26	0.105
76	A/C	1/11.5	15	20	30	0.154
			20	20	28	0.169
			22.5	20	27	0.199
			25	20	27	0.091
			27.5	20	27	0.126
77	A/C	1/30	15	20	30	0.124
			20	20	28	0.189
			22.5	20	27	0.265
			25	20	27	0.127
			27.5	20	27	0.141
78	B/C	1/3	22.5	20	29	-
			25	20	30	-
			27.5	20	30	-

TABLE IV (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
79	B/C	1/7	15	20	31	-
			20	20	31	-
			22.5	20	31	0.493
			25	20	28	0.227
			27.5	20	28	0.168
80	B/C	1/11.5	15	20	30	-
			20	20	31	0.235
			22.5	20	30	0.152
			25	20	26	0.113
			27.5	20	28	0.116
81	B/C	1/30	15	20	30	0.161
			20	20	28	0.147
			22.5	20	26	0.187
			25	20	25	0.085
			27.5	20	26	0.136

The effects of mixing are shown in Table V. An enzyme broth is treated with the blends, the clinical test tube being inverted from 10 to 100 times in Examples 82 and 83. As can be seen, undue agitation appears to deleteriously affect mechanical break-up of flocculated particles, leading to the creation of many fines. The same trend can be seen in Examples 84-89, in Examples 90-95 and in Examples 96-107.

TABLE V

Mixing Factor vs. Compaction and Supernatant Clarity

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
82	A/C	1.3/1	20	10	21	0.162
			20	20	20	0.195
			20	30	20	0.201
			20	50	20	0.284
			20	75	20	0.363
			20	100	20	0.397
83	B/C	1.3/1	20	10	23	0.143
			20	20	21	0.225
			20	30	20	0.179
			20	50	18	0.222
			20	75	20	0.347
			20	100	20	0.534
84	A/C	1/1.5	16	20	21	0.198
			18	20	21.5	0.085
			20	20	21	0.079
			22	20	20	0.058
			24	20	20.5	0.047
85	A/C	1/1.5	16	40	22	0.374
			18	40	20.5	0.229
			20	40	21	0.078
			22	40	21	0.102
			24	40	20	0.074

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
86	A/C	1/1.5	16	75	22	0.358
			18	75	24	0.441
			20	75	22	0.655
			22	75	22	0.400
			24	75	22	0.293
87	B/C	1/1.5	16	20	21	0.529
			18	20	20.5	0.360
			20	20	20	0.464
			22	20	20.5	0.365
			24	20	20	0.435
88	B/C	1/1.5	16	40	20	0.233
			18	40	20	0.095
			20	40	19.5	0.078
			22	40	20	0.102
			24	40	19.5	0.107
89	B/C	1/1.5	16	75	20.5	0.404
			18	75	19.5	0.338
			20	75	21	0.147
			22	75	20.5	0.351
			24	75	20	0.101

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
90	A/C	1/1.5	16	20	22.5	0.301
			18	20	23	0.164
			20	20	23.5	0.125
			22	20	24	0.114
			24	20	24	0.094
91	A/C	1/1.5	16	40	24	0.335
			18	40	23	0.318
			20	40	22.5	0.220
			22	40	22.5	0.112
			24	40	22.5	0.059
92	A/C	1/1.5	16	75	22.5	1.503
			18	75	22.5	1.426
			20	75	23	0.834
			22	75	22.5	0.280
			24	75	22.5	0.338
93	B/C	1/1.5	16	20	22	0.795
			18	20	22.5	0.219
			20	20	23	0.184
			22	20	24	0.153
			24	20	23	0.145

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
94	B/C	1/1.5	16	40	21.5	0.696
			18	40	22	0.377
			20	40	22	0.248
			22	40	22.5	0.208
			24	40	22	0.147
95	B/C	1/1.5	16	75	20	-
			18	75	20.5	1.927
			20	75	22.5	1.504
			22	75	20.5	1.303
			24	75	22	0.808
96	A/C	3/1	16	40	22.5	0.663
			18	40	22.5	0.661
			20	40	22	0.314
			22	40	22	0.064
			24	40	22.5	0.216
97	A/C	3/1	16	75	22.5	1.18
			18	75	21.5	0.823
			20	75	23	0.598
			22	75	21	0.570
			24	75	22.5	0.107

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
98	A/C	1/1.5	16	40	23	0.515
			18	40	22	0.420
			20	40	23.5	0.210
			22	40	21	0.077
			24		22	0.159
99	A/C	1/1.5	16	75	23.5	0.688
			18	75	22.5	0.586
			20	75	22	0.366
			22	75	22	0.295
			24	75	22.0	0.084
100	A/C	1/3	16	40	23	0.293
			18	40	22.5	0.183
			20	40	25	0.087
			22	40	25	0.071
			24	40	25	0.042
101	A/C	1/3	16	75	23	0.285
			18	75	25	0.252
			20	75	24	0.117
			22	75	25	0.179
			24	75	25	0.063

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/1 Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
102	B/C	3/1	16	40	22	0.551
			18	40	20	0.310
			20	40	21	0.152
			22	40	20	0.088
			24	40	22	0.093
103	B/C	3/1	16	75	20	0.538
			18	75	21	0.295
			20	75	21	0.223
			22	75	19.5	0.120
			24	75		
104	B/C	1/1.5	16	40	22	0.275
			18	40	20.5	0.088
			20	40	20	0.065
			22	40	20	0.038
			24	40	21.5	0.052
105	B/C	1/1.5	16	75	21.5	0.058
			18	75	21.5	0.064
			20	75	21	0.143
			22	75	20	0.098
			24	75	22	0.095

TABLE V (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
106	B/C	1/3	16	40	21.5	0.069
			18	40	20.5	0.051
			20	40	22	0.042
			22	40	22	0.046
			24		22.5	0.059
107	B/C	1/3	16	75	22	0.338
			18	75	22	0.256
			20	75	23	0.055
			22	75	22.5	0.079
			24	75	22.5	0.052

The broad effects of the blends of polymers of the present invention on an enzyme broth is shown in Table VI. The overall tread again supports the unique results achieved by said blends.

TABLE VI

Polymer Blend Ratios vs. Affect on Compaction and Clarity of Supernatant at 40 Inversions

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
108	A/C	3/1	16	40	22	0.406
			18	40	23	0.290
			20	40	22.5	0.189
			22	40	22	0.141
			24	40	22	0.182
109	A/C	1/1.5	16	40	24	0.335
			18	40	23	0.318
			20	40	22.5	0.220
			22	40	22.5	0.112
			24	40	22.5	0.059
110	A/C	1/3	16	40	24.5	0.119
			18	40	24	0.115
			20	40	24.5	0.082
			22	40	25	0.162
			24	40	25.5	0.207
111	A/C	1/7	16	40	25	0.259
			18	40	25.5	0.064
			20	40	26	0.118
			22	40	27	0.106
			24	40	28.5	0.215

TABLE VI (Cont'd).

Exp. No.	Flocculant	Ratio	g/1 Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
112	A/C	1/30	16	40	29	0.123
			18	40	29	0.101
			20	40	29	0.106
			22	40	30	0.104
			24	40	30	0.066
113	B/C	3/1	16	40	20	0.860
			18	40	20.5	0.482
			20	40	20	0.356
			22	40	20	0.301
			24	40	20	0.235
114	B/C	1/1.5	16	40	21.5	0.696
			18	40	22	0.377
			20	40	22	0.248
			22	40	22.5	0.208
			24	40	22	0.147
115	B/C	1/3	16	40	22	0.057
			18	40	21	0.096
			20	40	22.5	0.062
			22	40	22	0.066
			24	40	22	0.110

TABLE VI (Cont'd).

Exp. No.	Flocculant	Ratio	g/l Flocculant	No. of Tube Inversions	Centrifuge 5 Minutes % Volume Solids	Clarity of Supernatant 660 Microns
116	B/C	1/7	16	40	23.5	0.078
			18	40	23.5	0.071
			20	40	24.5	0.068
			22	40	25	0.062
			24	40	25	0.019
117	B/C	1/30	16	40	28.5	0.172
			18	40	29	0.185
			20	40	29.5	0.169
			22	40	29.5	0.157
			24	40	30.5	0.145

Claims

1. A process for the flocculation of an aqueous enzyme broth which comprises adding to said broth a flocculant comprising a mixture of 1) a Mannich acrylamide polymer and 2) a dimethyldiallylammonium halide polymer.

2. A process according to Claim 1 wherein the ratio of 1) to 2) ranges from about 3:1 to about 1:30, by weight, respectively.

3. A process according to Claim 1 wherein the ratio of 1) to 2) ranges from about 1:1.5 to about 1:7, by weight, respectively.

4. A process according to Claim 1 wherein 1) is a Mannich homopolymer of acrylamide.

5. A process according to Claim 1 wherein 1) is a Mannich copolymer of acrylamide containing 5-50% of a comonomer.

6. A process according to Claim 1 wherein 1) contains 25-100 mol percent of dimethylaminomethyl groups.

7. A process according to Claim 1 wherein 2) is a chloride.

8. A process according to Claim 1 wherein 2) is polydimethyldiallylammonium chloride.

9. A process according to Claim 1 wherein the enzyme is a protease.

10. A process according to Claim 1 wherein from about 10 to 100 grams per liter of broth of polymer blend is added.

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(71) Applicant: **AMERICAN CYANAMID COMPANY**
1937 West Main Street P.O. Box 60
Stamford Connecticut 06904-0060(US)

(72) Inventor: **Cibulskas, Algrid S.**
28 Westwood Road
Stamford, Connecticut 06902(US)
Inventor: **Asbell, Henri R.**
51 Gilrix Drie
Martinez, California 94553(US)

(74) Representative: **Wächtershäuser, Günter, Dr.**
Tal 29
W-8000 München 2(DE)

(54) Use of blends of mannich acrylamide polymers and dimethyldiallylammonium halide polymers for flocculating enzyme broth streams.

(57) Blends of Mannich acrylamide polymers and dimethyldiallylammonium halide polymers have been found to be superior flocculants for enzyme broth streams yielding higher solid compaction and greater supernatant clarities than the use of either polymer alone.

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EUROPEAN SEARCH REPORT

Application Number

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US - A - 4 508 825 (KIM et al.) * Abstract * --	1,9	C 12 N 9/00 C 12 N 9/50
A	PATENT ABSTRACTS OF JAPAN, unexamined applications, C field, vol. 13, no. 69, February 16, 1989 THE PATENT OFFICE GOVERNEMENT page 9 C 569 * Kokai-no. 63-258 607 (EBARA INFILCO) * --	1	
D,A	US - A - 4 137 164 (COSCIA et al.) * Abstract * --	1	
D,A	US - A - 4 092 467 (WELCHER et al.) * Abstract * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C 12 N
B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	25-11-1991	WOLF

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